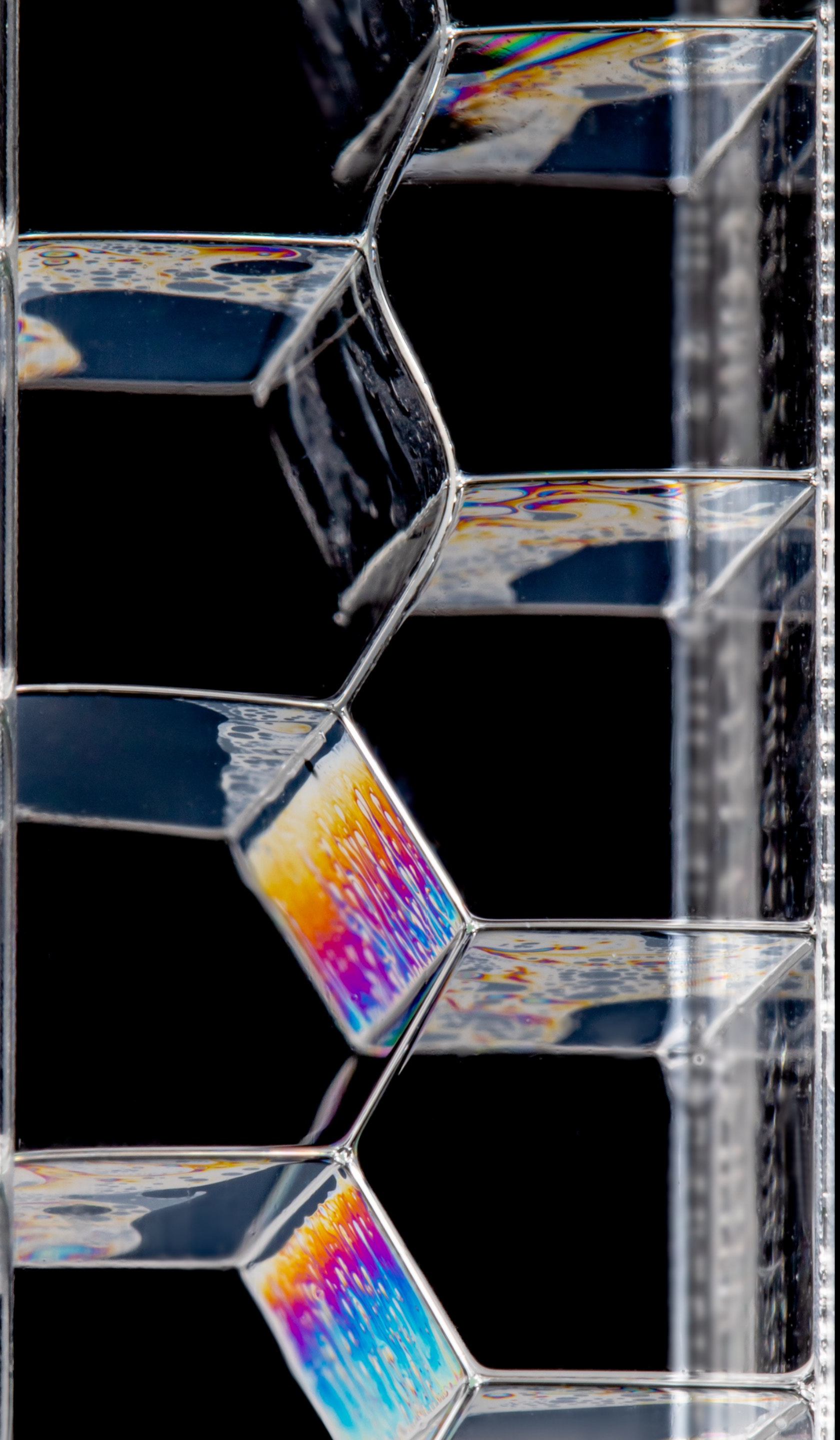

1 mm

Foams and soft intruders:

Exploiting elastocapillarity towards novel foam structures

Interdisciplinary thematic institutes
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Institut Charles SADRON
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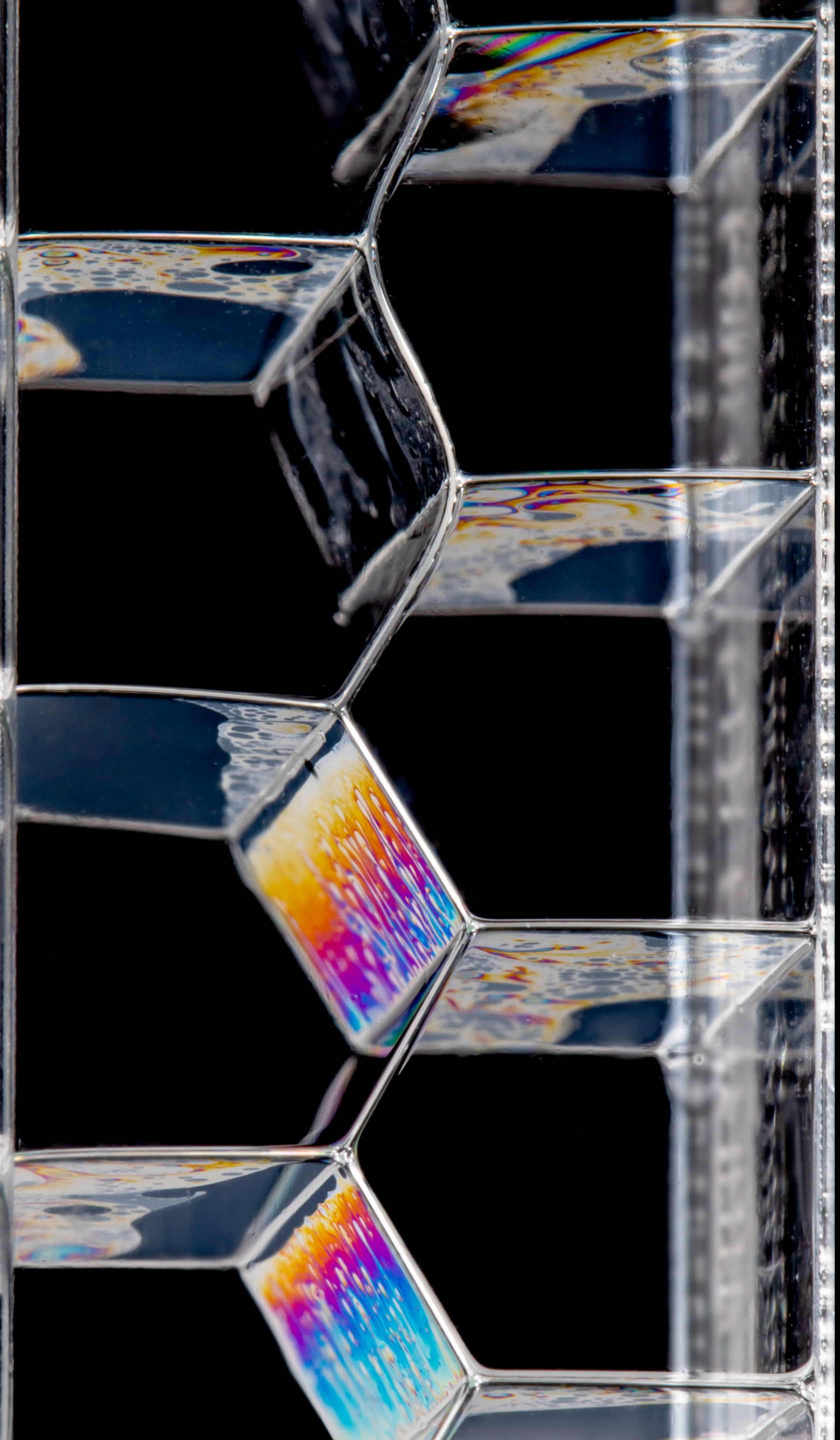
Congrès Général SFP - July 3rd, 2022

Manon Jouanlanne, Antoine Egelé, Guillaume Cotte-Carluer, Damien Favier, Wiebke Drenckhan, Jean Farago & Aurélie Hourlier-Fargette



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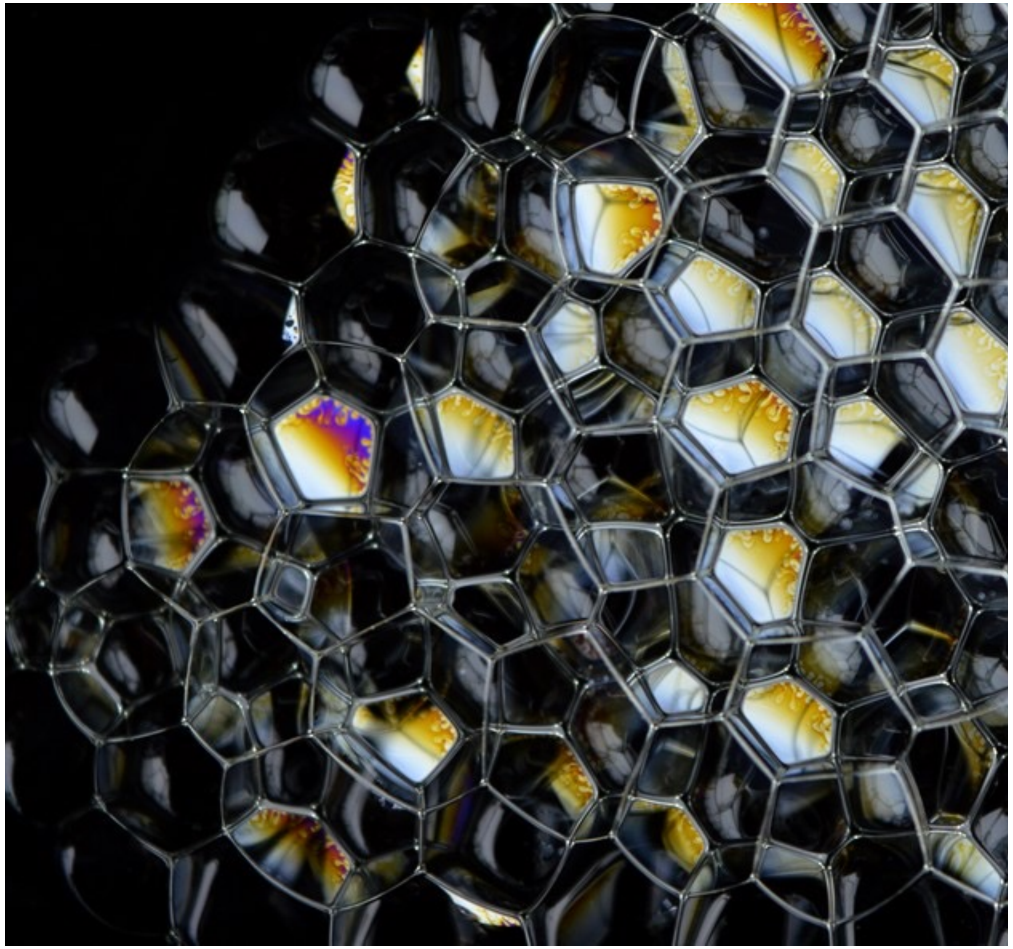
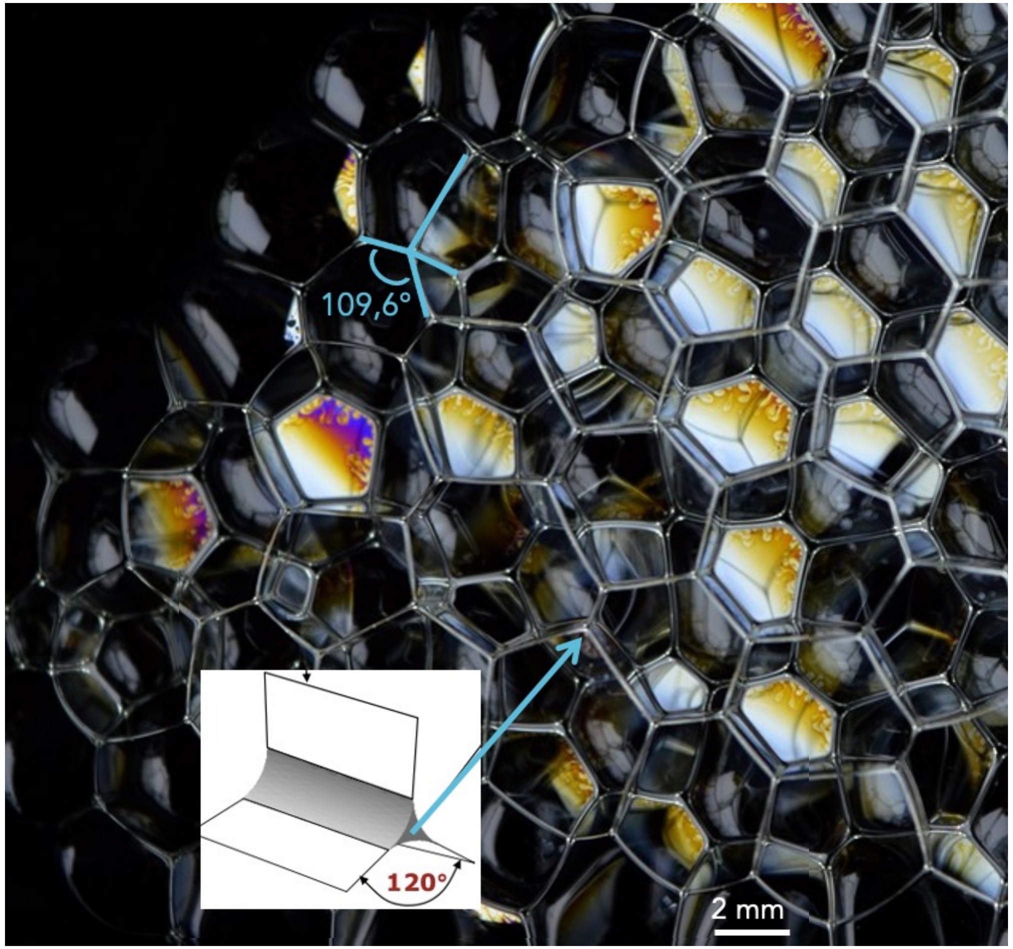
Foam structures



Foam structures

Liquid foam structure follows Plateau's rules (low density limit)



1. 3 films meet at 120° angles and form a Plateau Border
2. 4 Plateau Borders meet with 109,6° angles
3. Each film has a constant curvature

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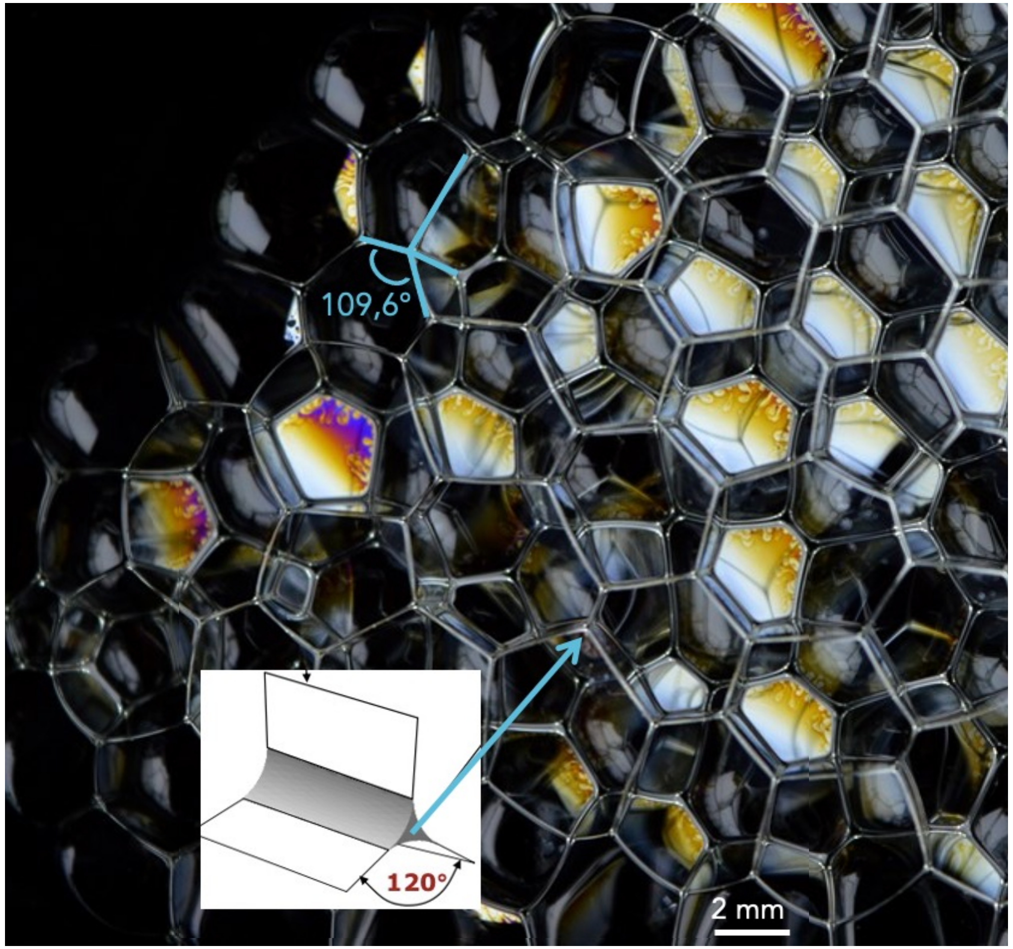

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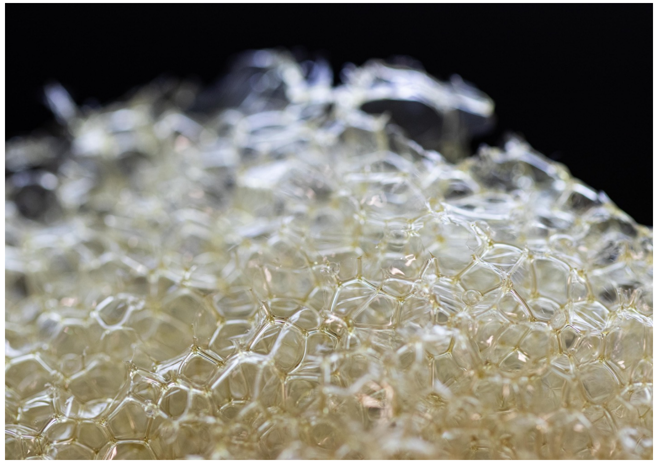
Liquid foams



Solid foams

"Liquid foam templating"

Andrieux et al, Adv. Coll. Int. Science, 2018

Why is the structure so important?

Properties of a cellular solid = Constitutive material properties E_s + Topology and geometry of cells + Relative density $\frac{\tilde{\rho}}{\rho_S}$

M.F. Ashby, Philosophical Transactions of the Royal Society A (2006)

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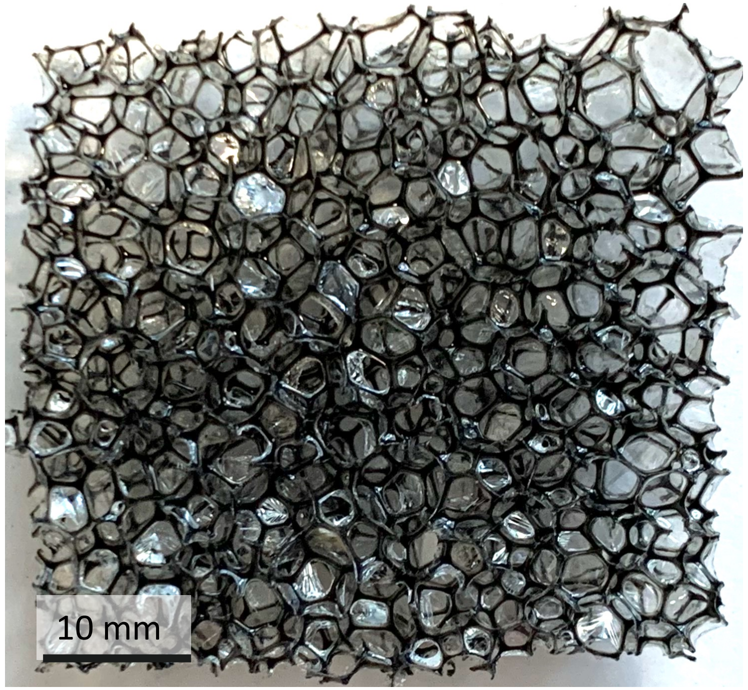
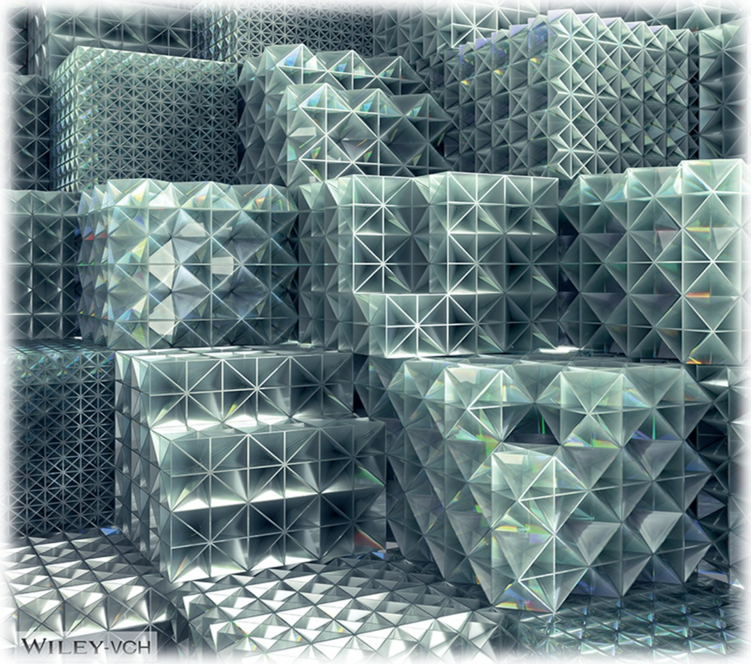
FOAMS



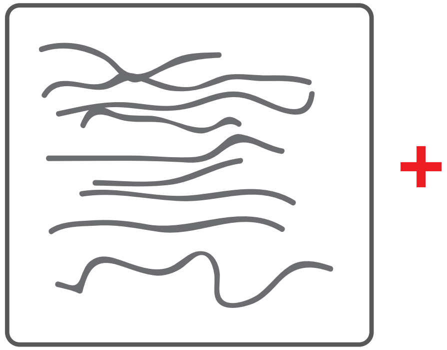
3D PRINTED ARCHITECTURES



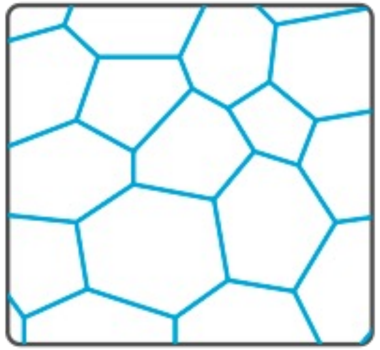
Tancogne-Dejean et al. Adv. Mat. 2018

Modifying foam structures of liquid precursors

Can we use elastic intruders to modify those mechanically self-assembled structures?



Elastic intruders



Liquid foam

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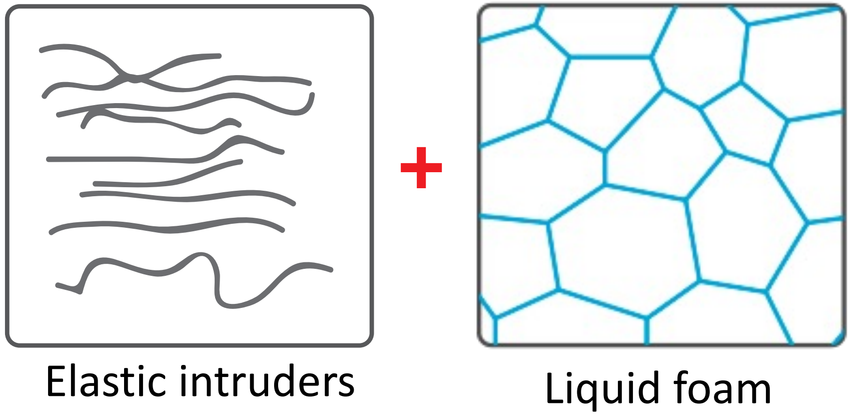
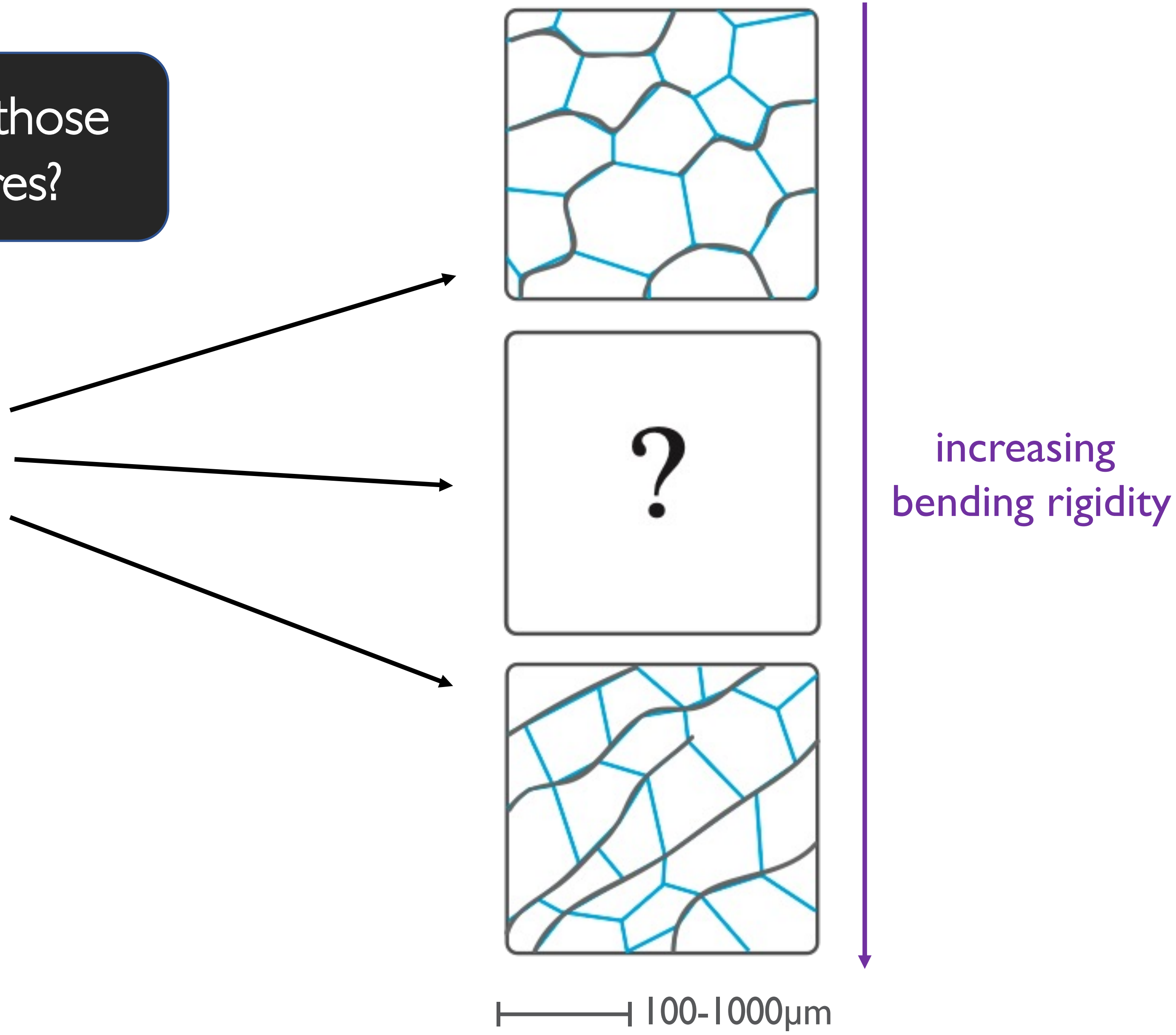




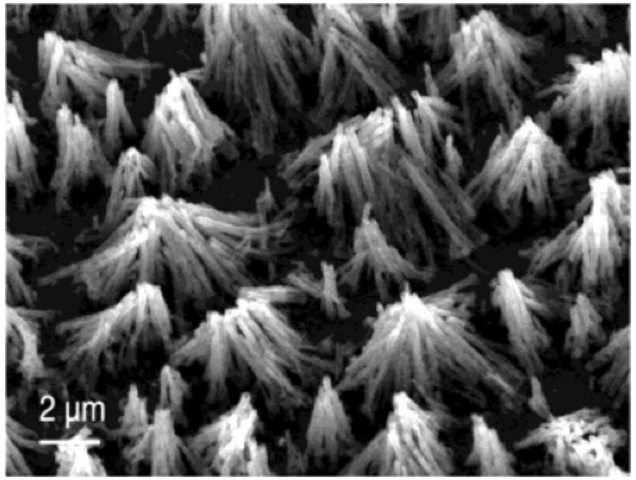
energies

interfacial $\sum(\gamma_i A_i)$

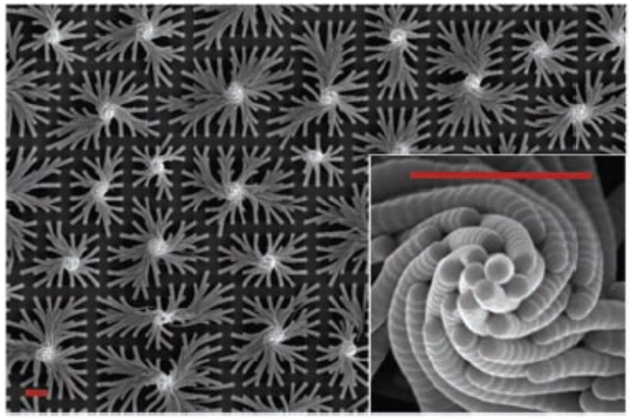
bending $\sim \frac{1}{2}\int_0^L B(\kappa(s)-\kappa_o)^2 ds$

Elastocapillarity (slender elastic structures + liquid interfaces)

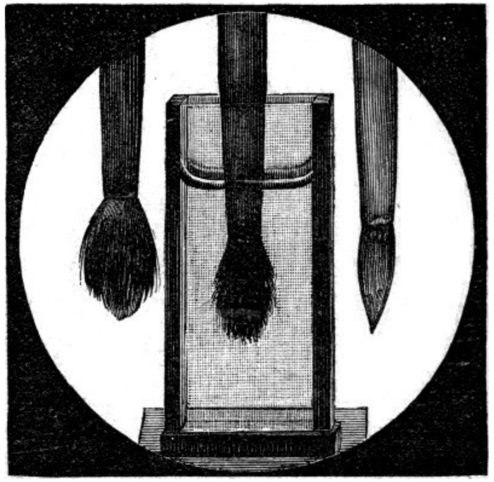
Py et al, PRL (2007)



K Lau et al, Nanoletters (2003)



B. Pokroy et al, Science (2009)



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Review articles : Roman et al, Journal of Physics: Condensed Matter (2010)
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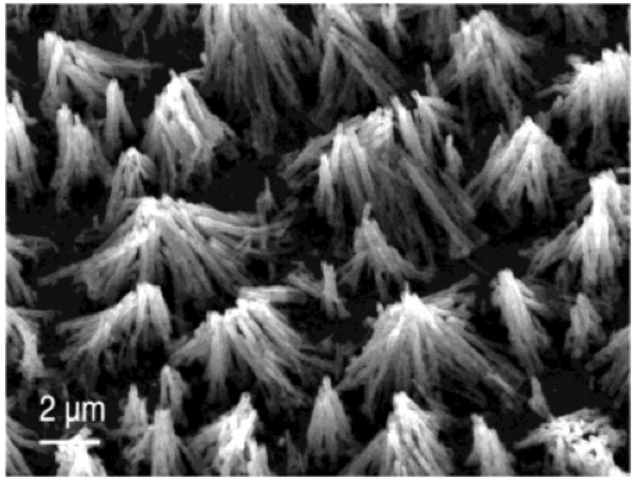

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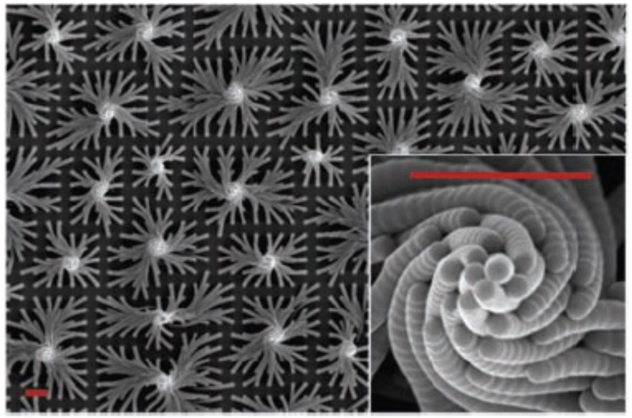


B. Pokroy et al, Science (2009)

Liquid/Interface

surface tension γ

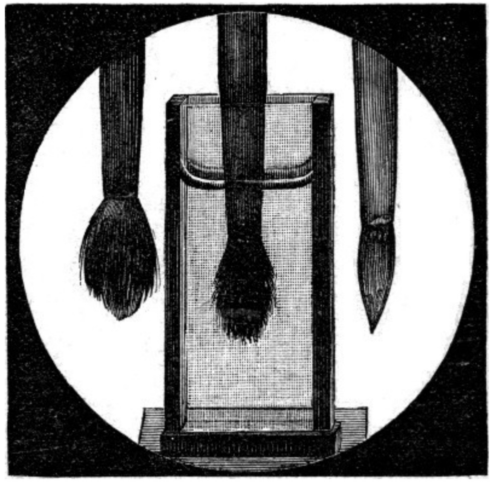
Elastic material

Young's modulus E

Geometry

bending rigidity

geometry of interfaces



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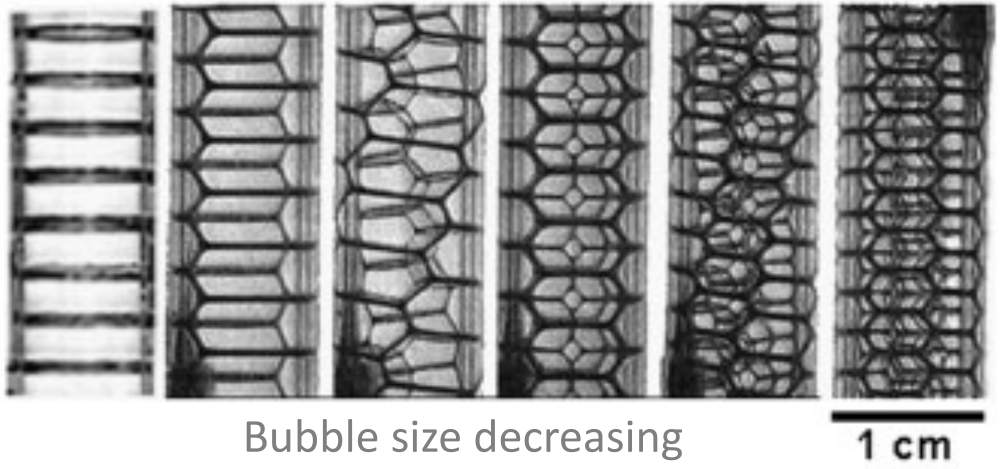
2D model system: confining bubbles in tubes

Ordered structures in cylindrical tubes

W. Drenckhan et al, Cur. Op. in Colloid & Interf. Science, 2010



Bubble size decreasing

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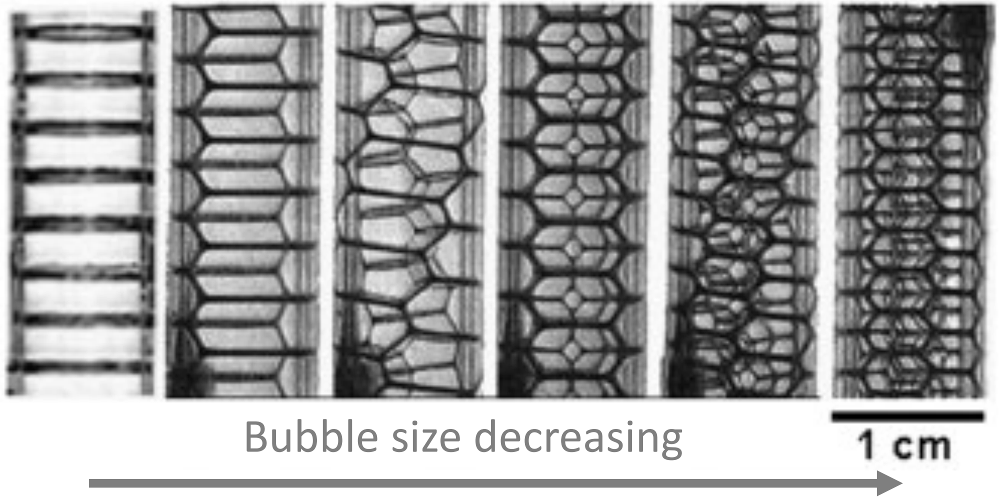
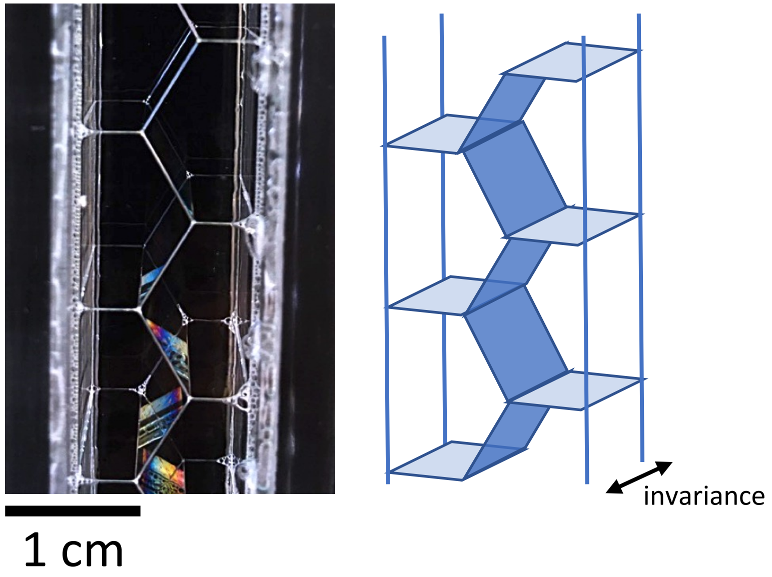


Staircase structure in square cross-section tube



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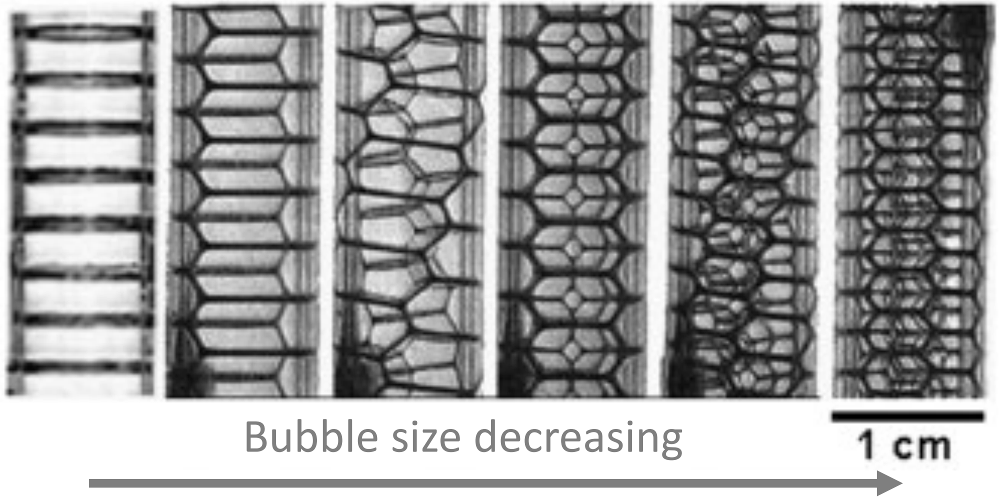

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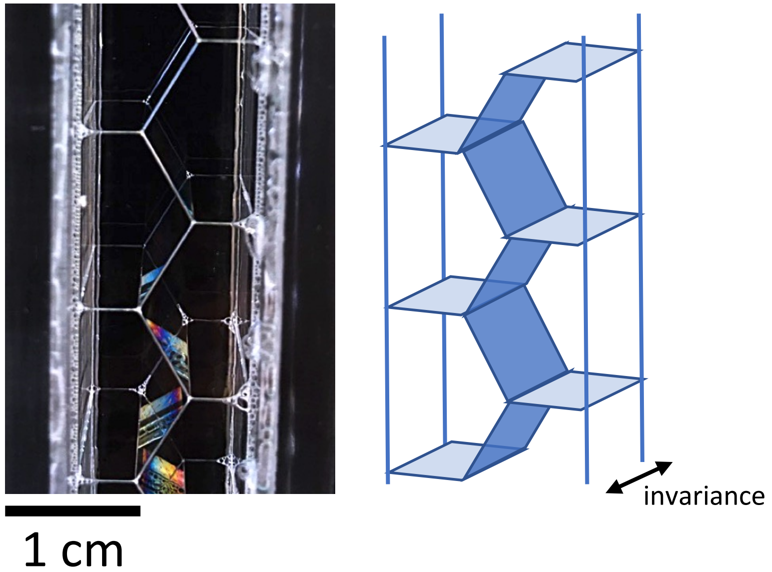

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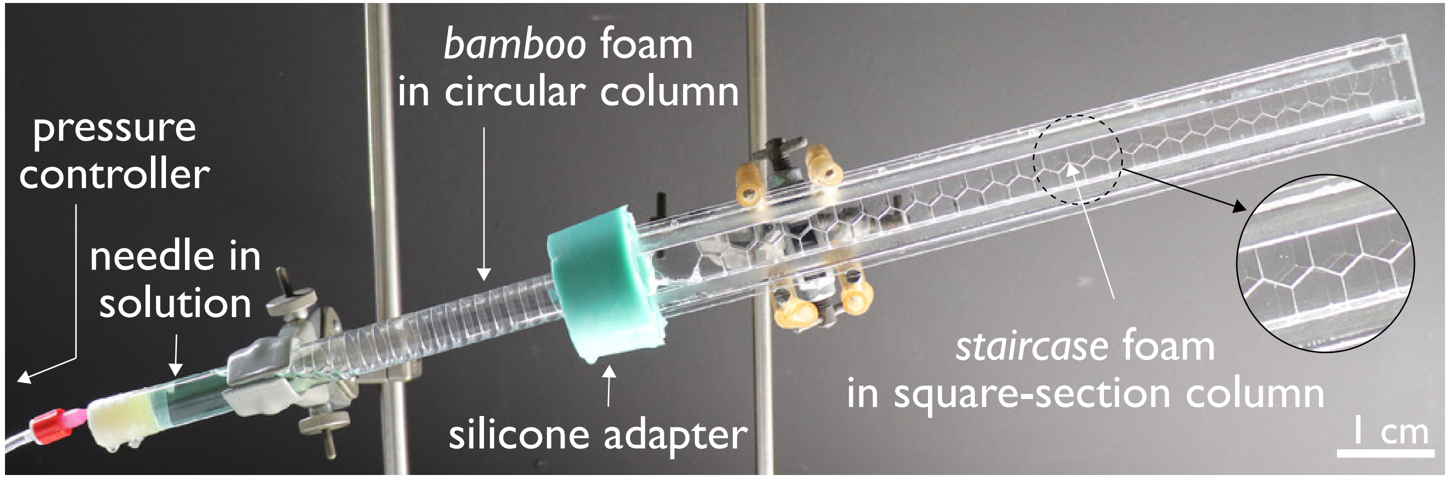

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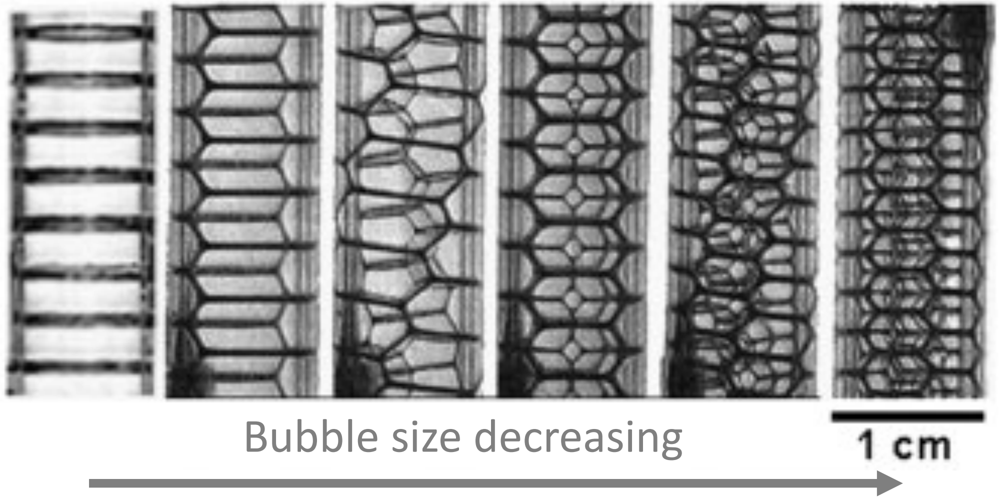

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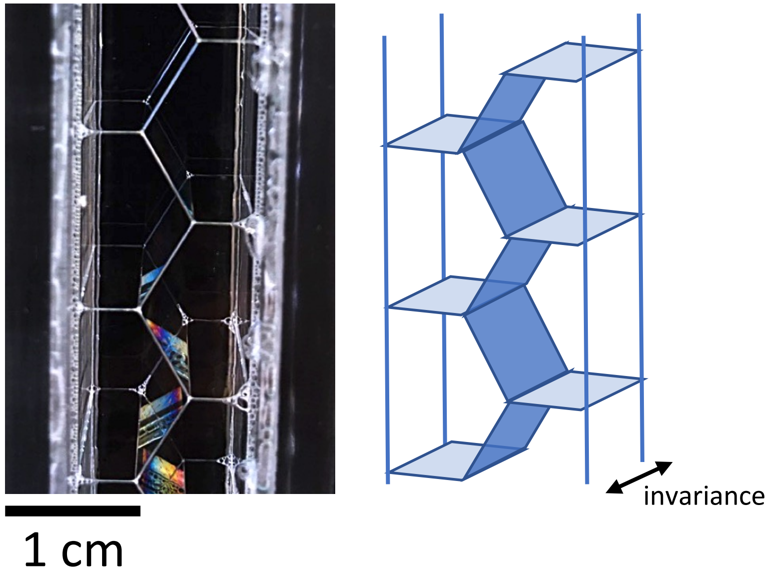

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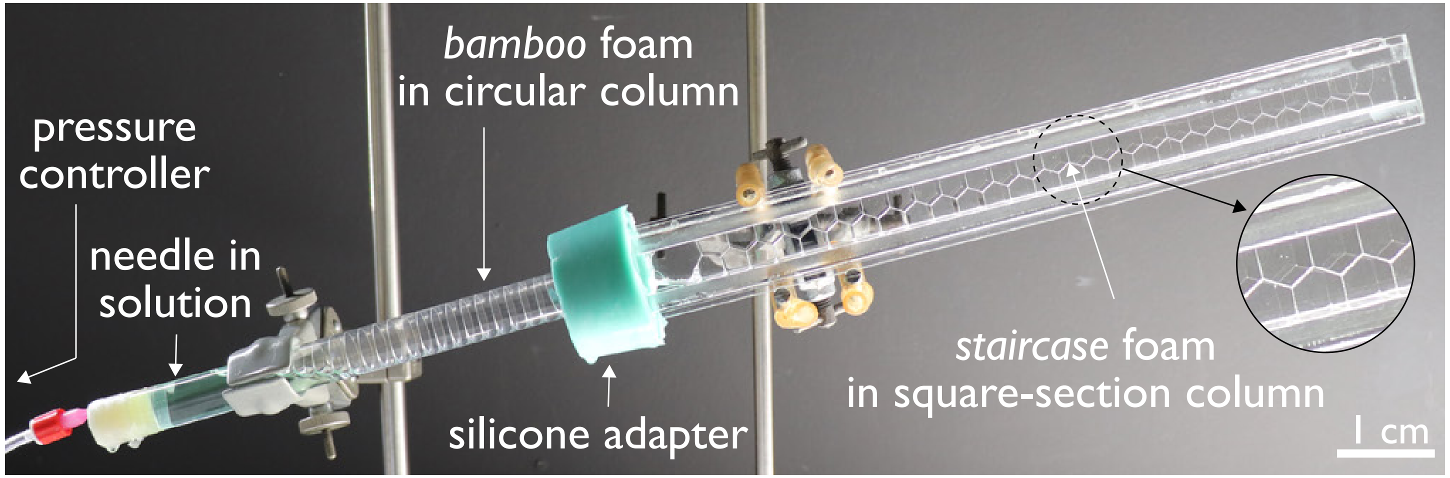
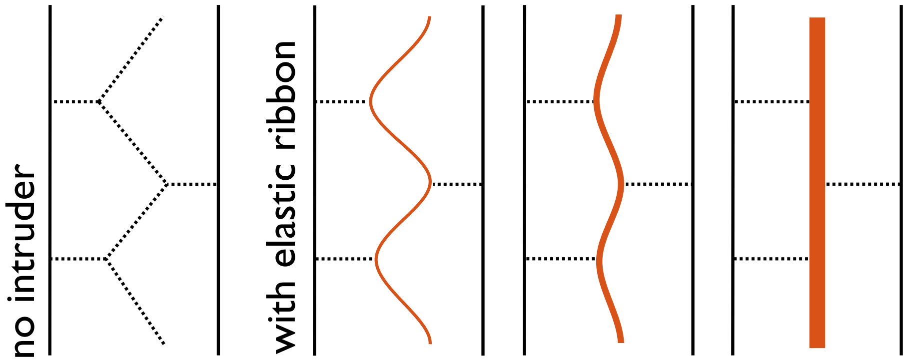
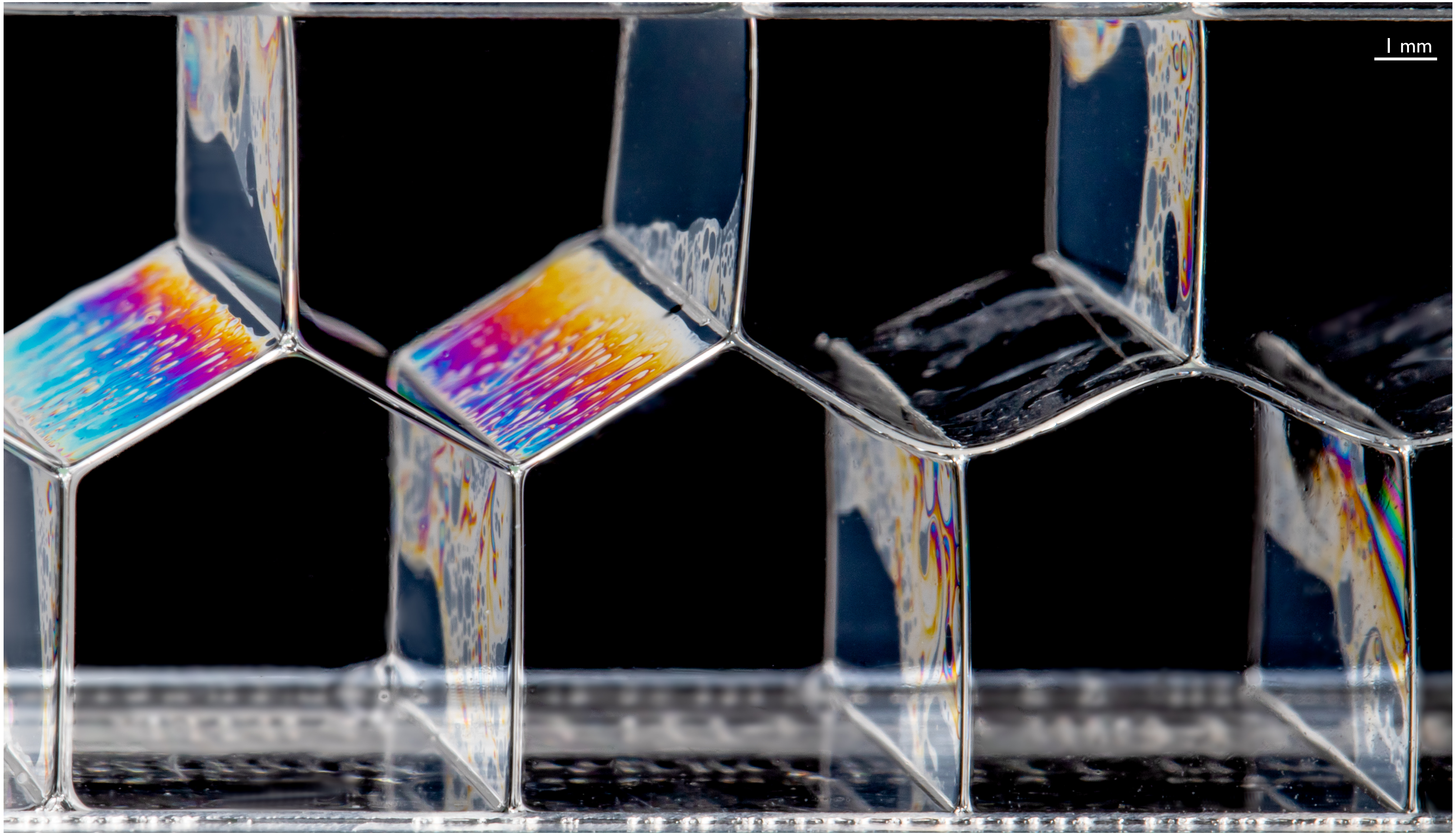


Insertion of an elastic ribbon



Bubble column + ribbon



X-ray tomography measurements

Minamec platform, ICS


Antoine Egelé & Damien Favier
Engineers

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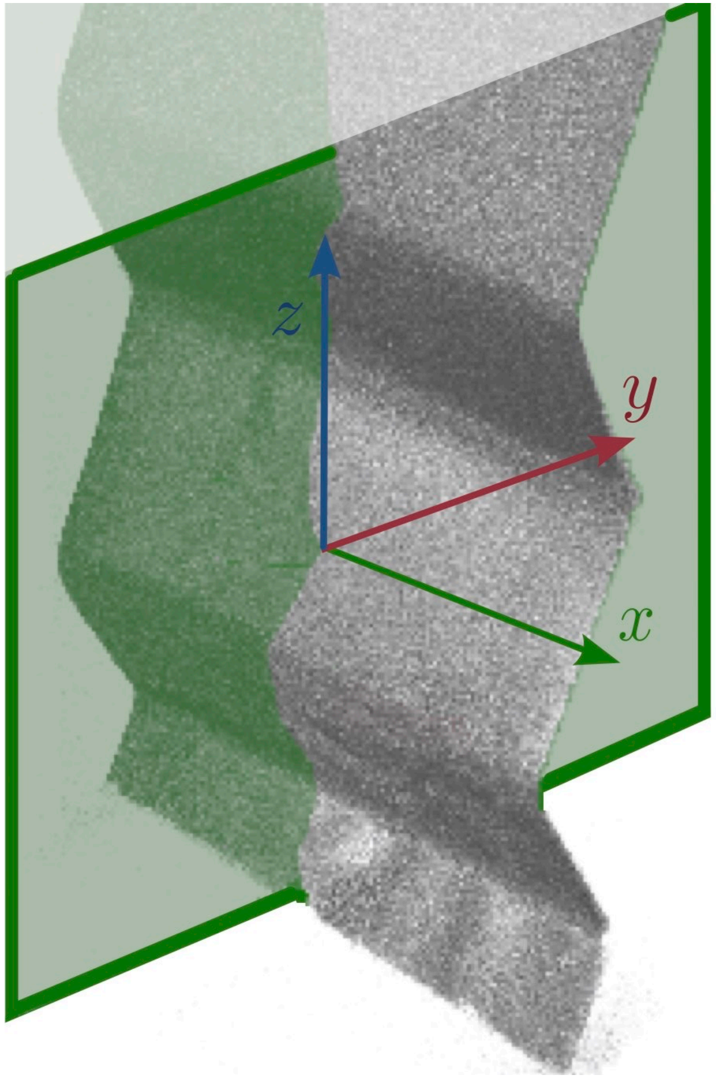
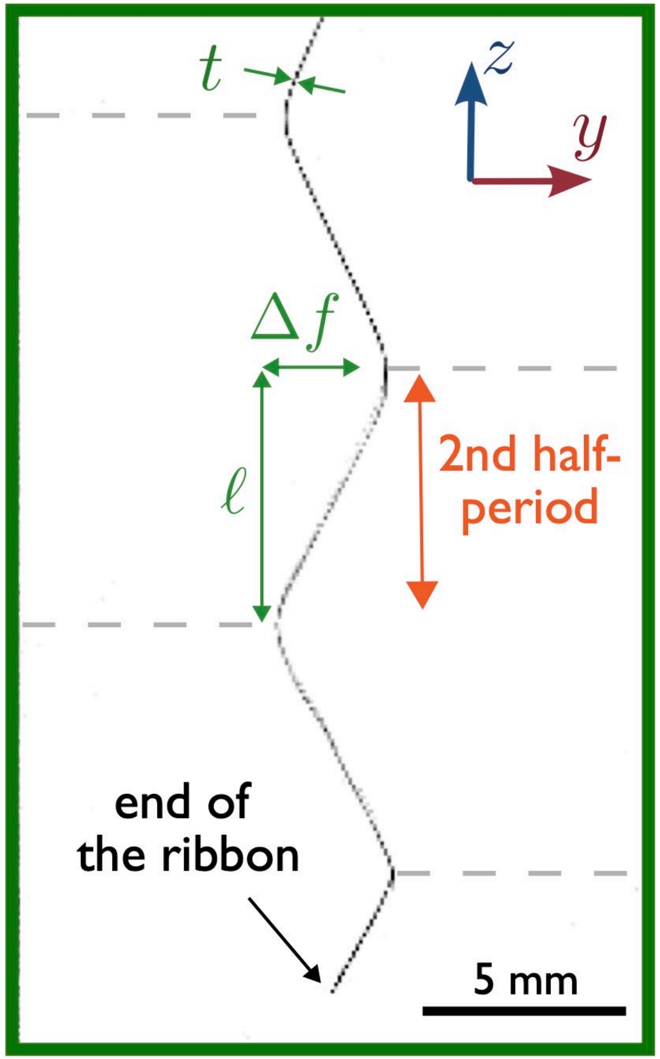
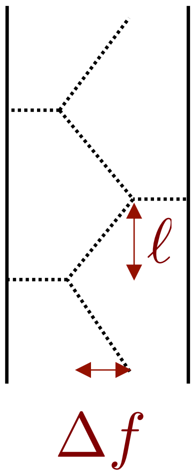




Modeling via energy minimisation

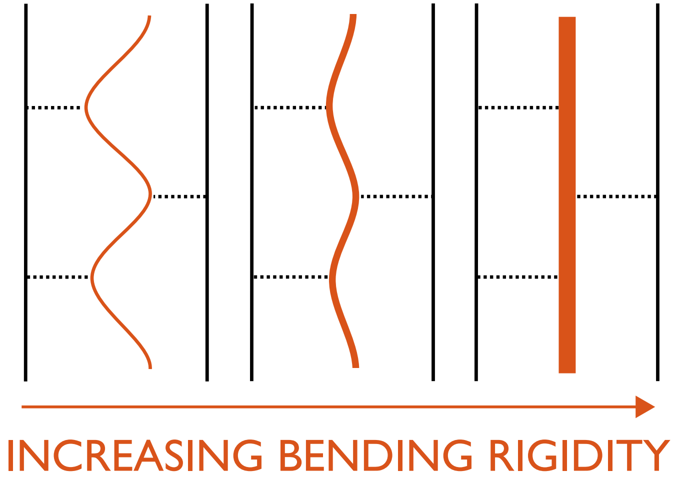
without intruder

$$\frac{\Delta f}{l} = \frac{1}{\sqrt{3}}$$



with intruder

$$\Delta f = ?$$



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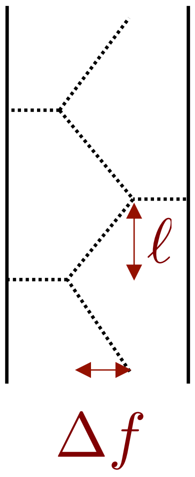

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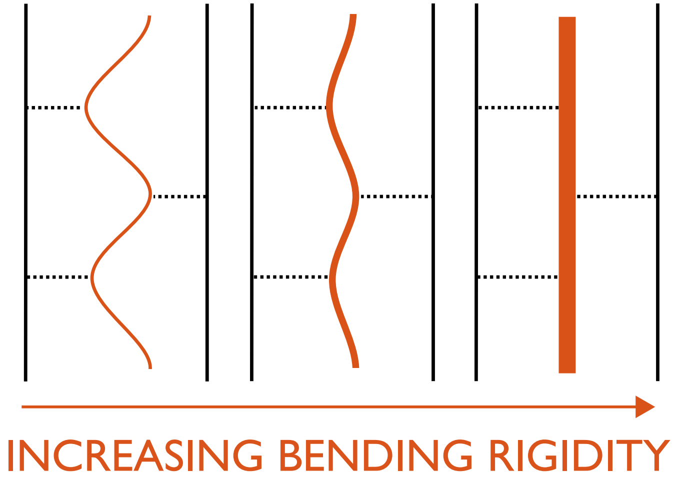
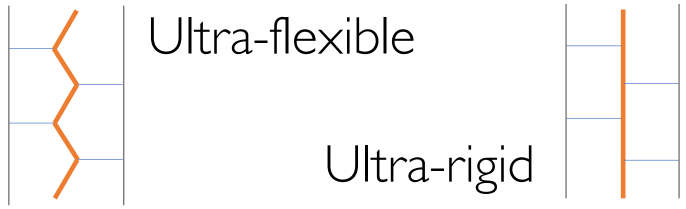


Energy minimisation (Euler-Lagrange) with constant ribbon total length L

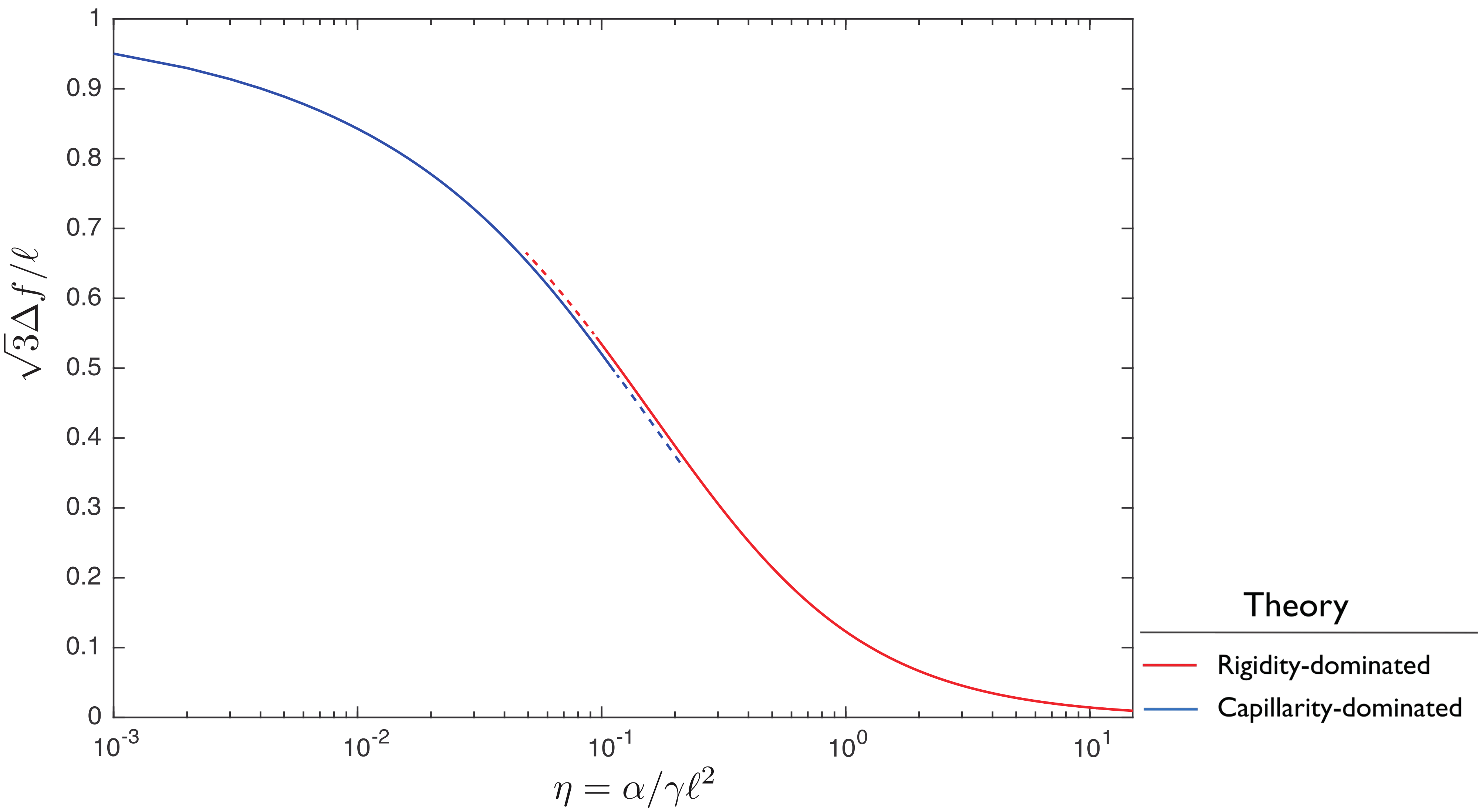
$$E_{\text{tot}} = E_{\text{bending}} + E_{\text{interfaces}} - E_{\text{interfaces without ribbon}}$$

- Number of bubbles in contact with the ribbon not constant
- Quadratic approximation around two limit cases →
- Resolution provides $\frac{\sqrt{3}\Delta f}{l}$ as a function of $\eta = \frac{B}{w\gamma l^2} = \frac{\alpha}{\gamma l^2}$



Deflexion vs elasticity/capillarity competition

Dimensionless deflection as a function of the parameter η comparing bending rigidity and capillarity



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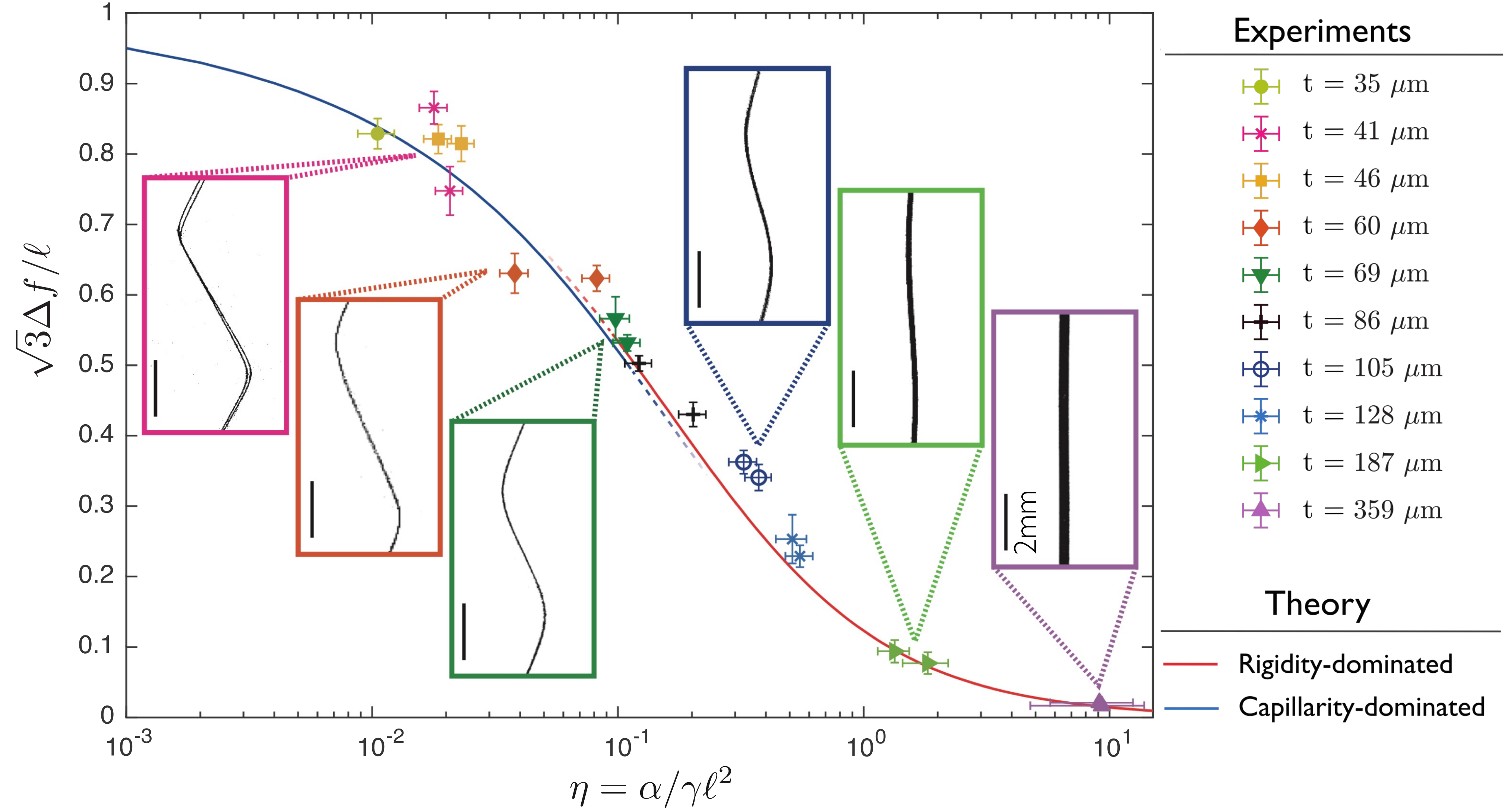

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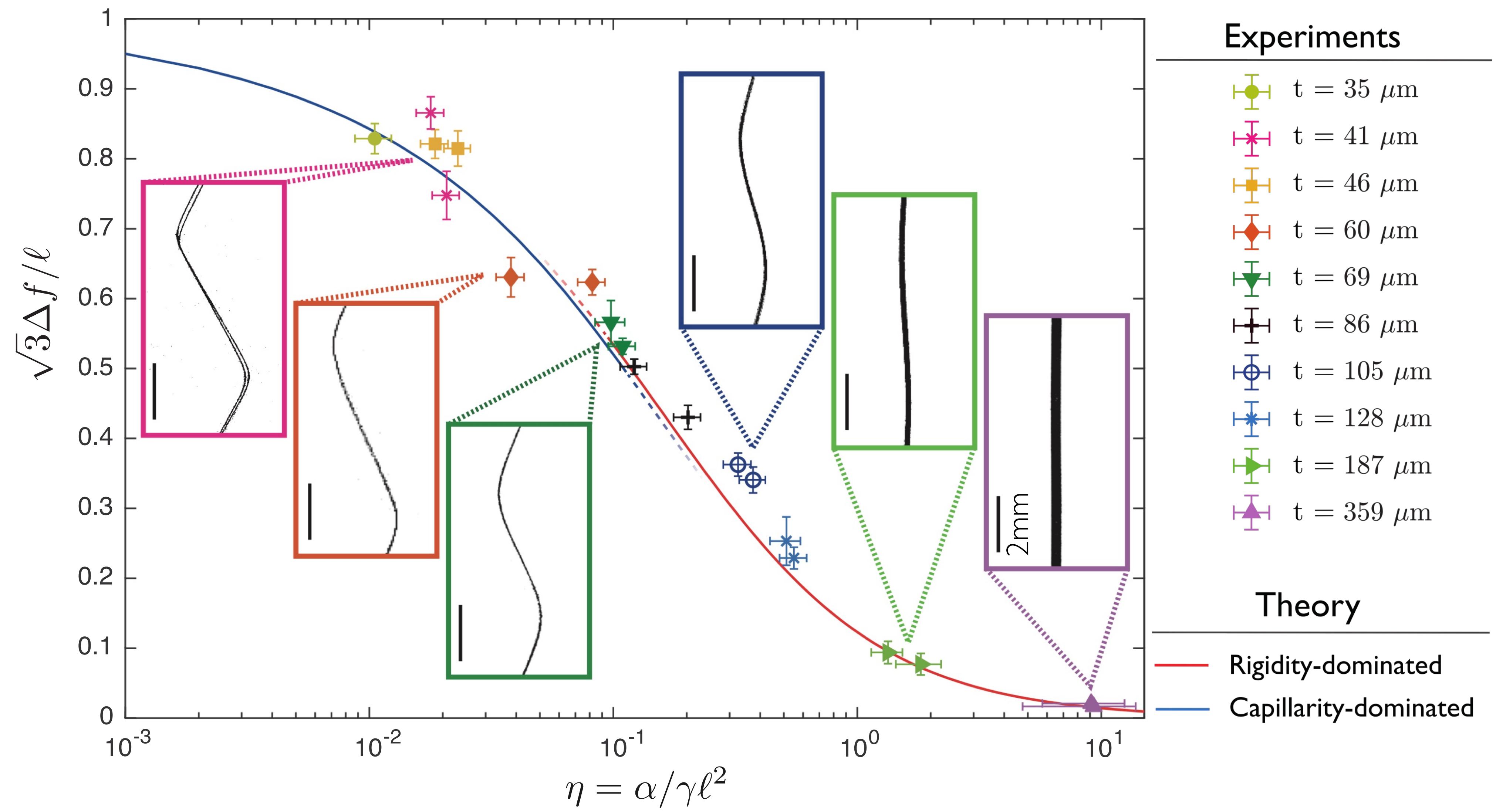
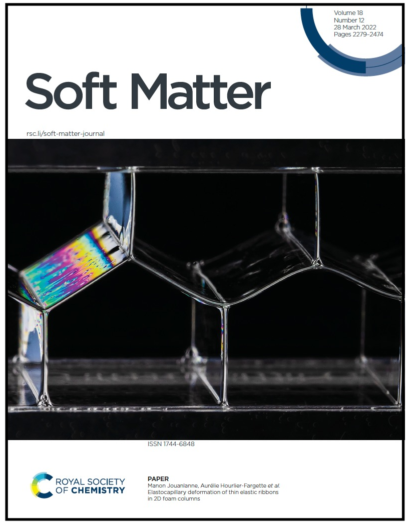
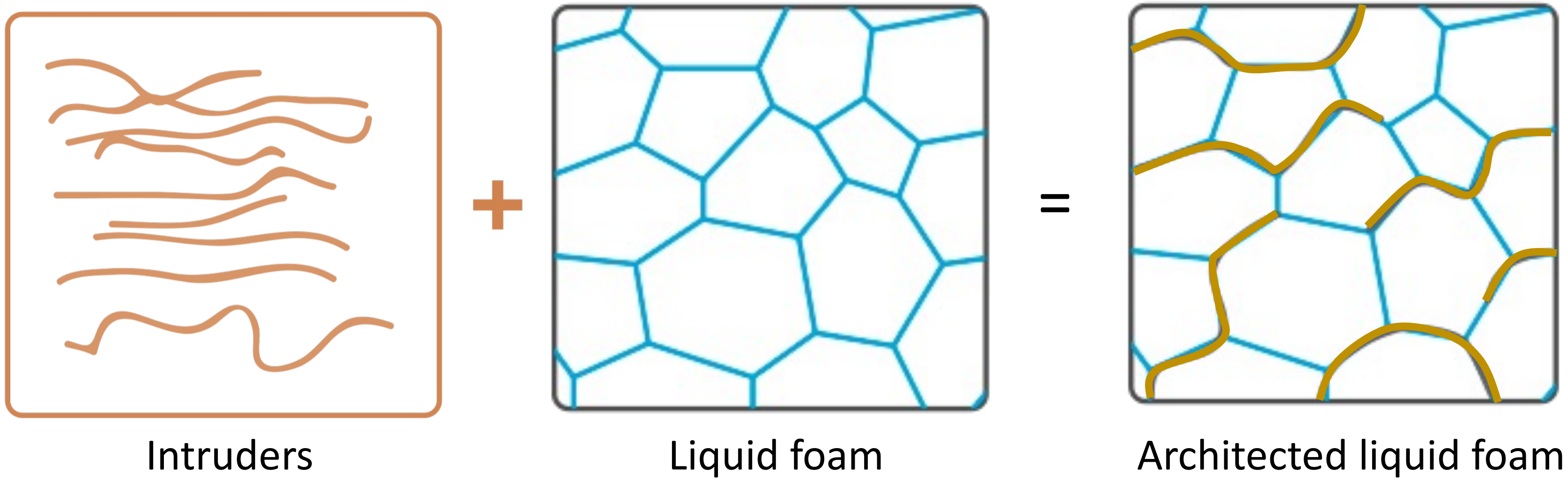




M. Jouanlanne et al, Soft Matter 2022, https://doi.org/10.1039/D1SM01687C

Gallery of Soft Matter 2022

Towards 3D solid complex systems



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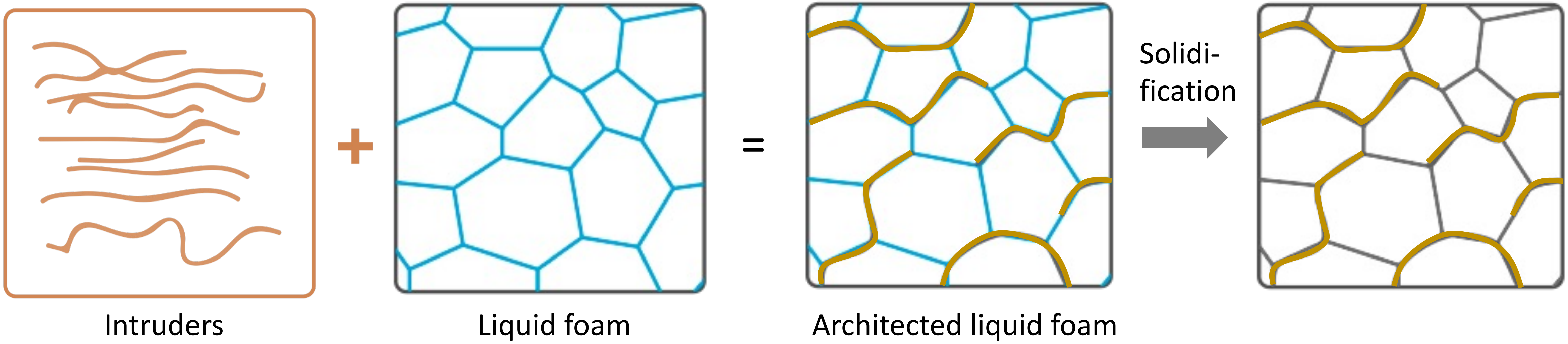
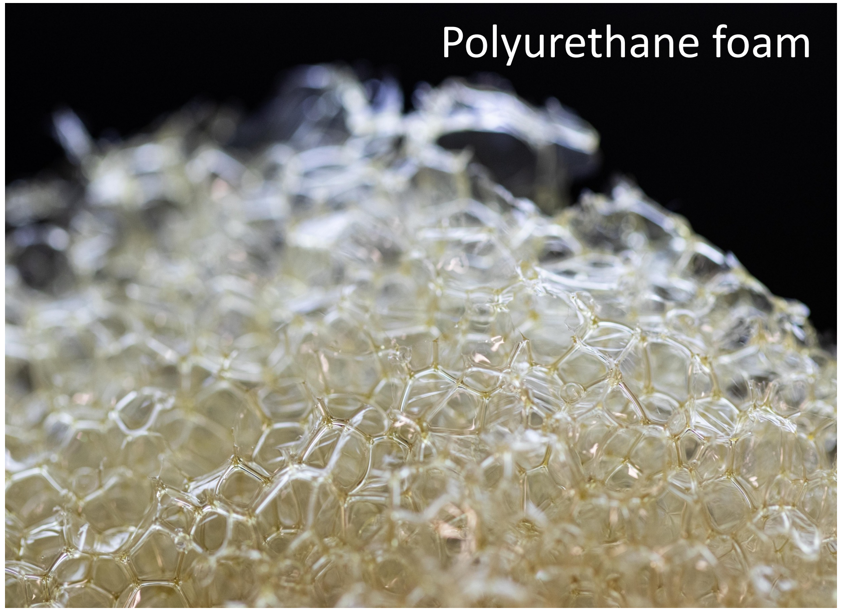
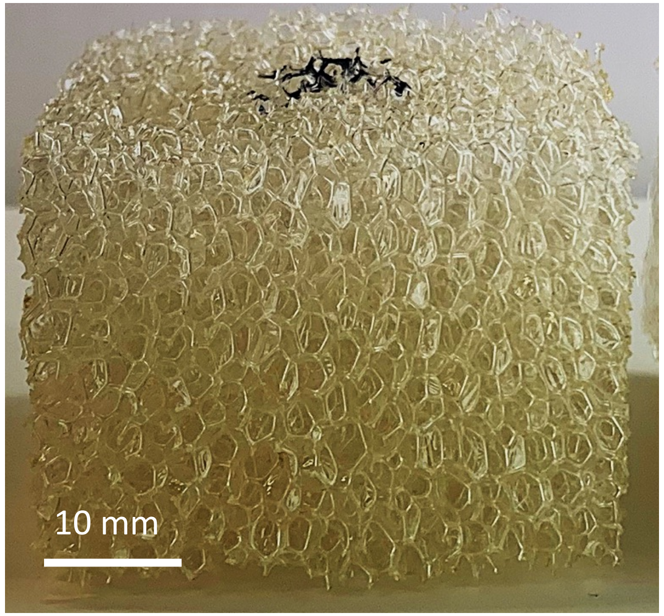
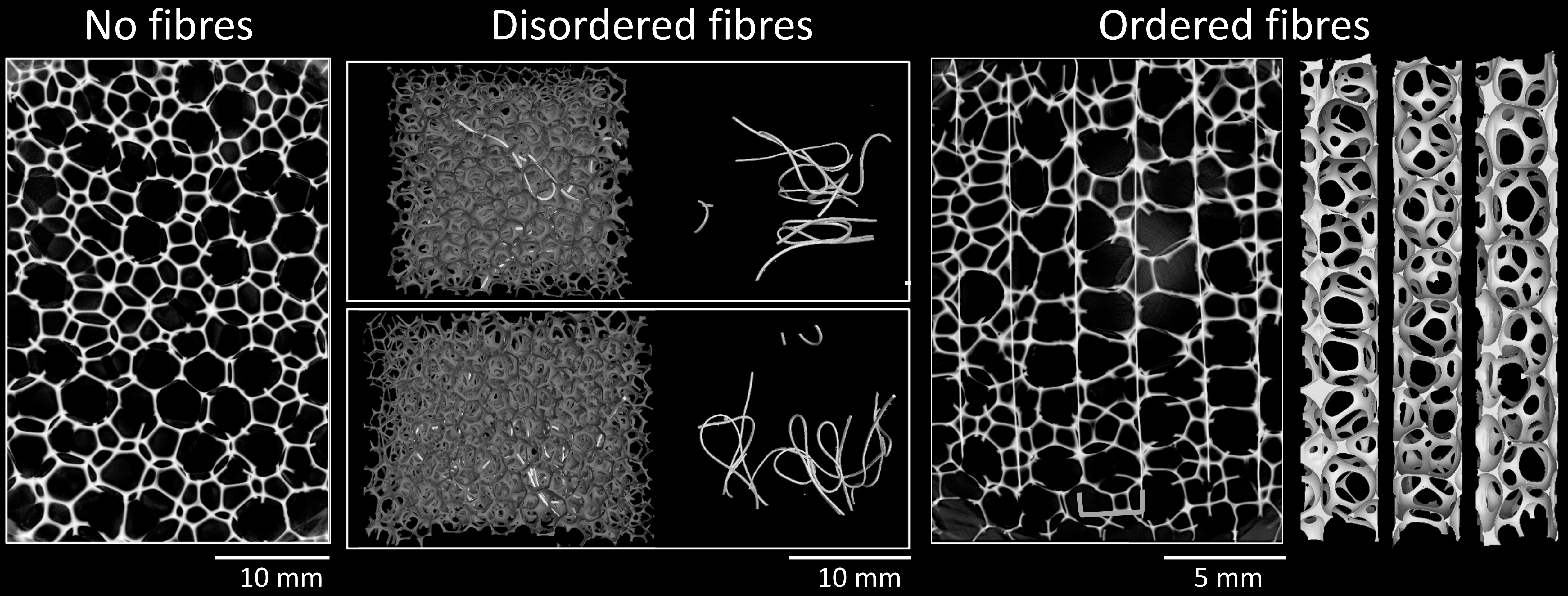






[Andrieux et al. ACIS 2018
Testouri et al. Adv. Eng. Mat. 2013}

Towards 3D solid complex systems



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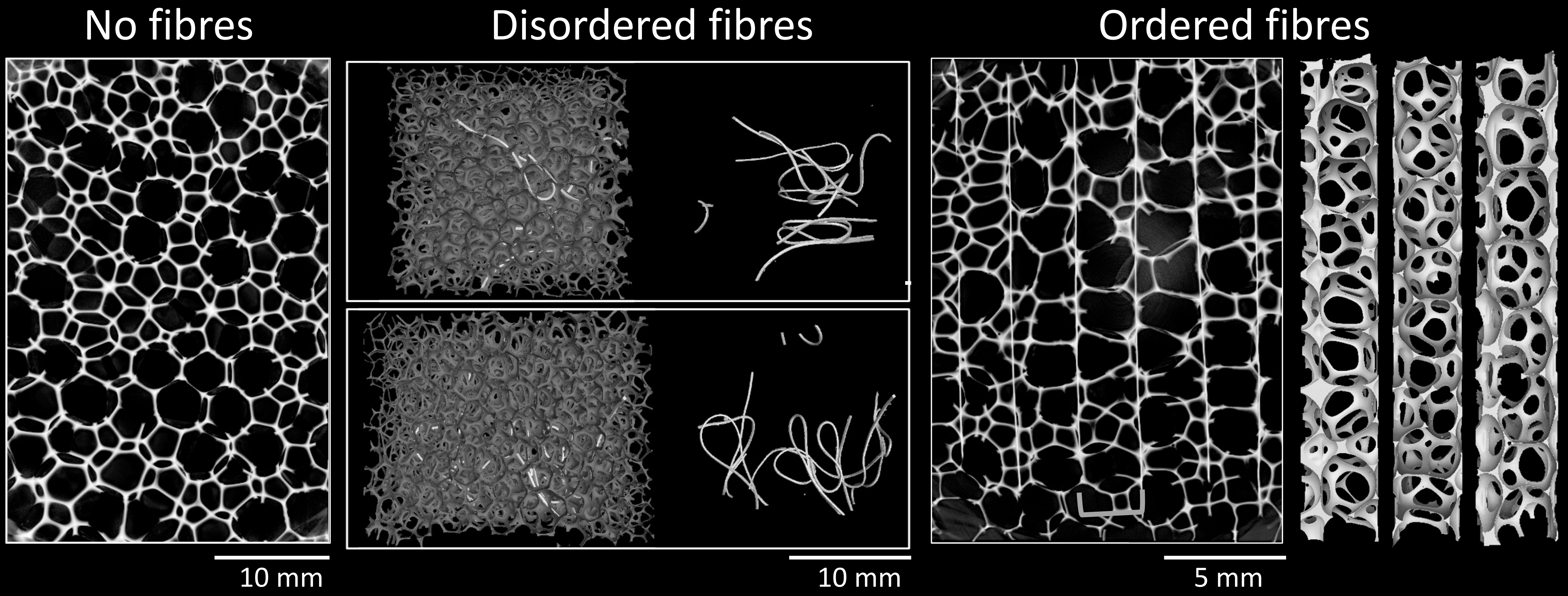

Structural characterisation?

Structure/property relations?

Thanks!

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Postdoc offer : CNRS Emploi https://t.co/fZfqzac08Z

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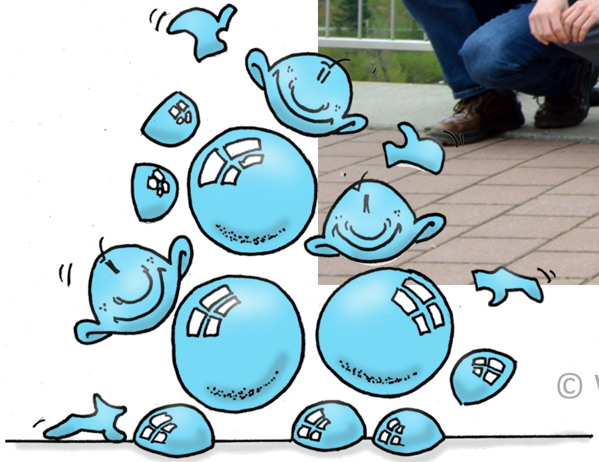

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Thank you for your attention!